IMPACT OF CLEARCUT SIZE ON WHITE-TAILED DEER USE AND TREE REGENERATION

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ABSTRACT. Northeastern forests have experienced regeneration delays and/or failures due to browsing by white-tailed deer (Odocoileus virginianus). Investigations were made in north-central West Virginia to determine if the size of clearcut is correlated with degree of deer browsing, regeneration of shrubs and trees, and percent ground cover by various herbaceous plants. Tree seedlings, woody shrubs, and herbaceous ground cover were recorded in September 1992 and August 1993 on 16, 1-year old clearcuts, ranging in size from 0.8 to 0.2 ha. Woody regeneration was categorized by species, origin, browsed or not, and vegetative height class on 25 systematically arranged sampling stations within each clearcut. Herbaceous plant cover (ferns, grasses, and sedges) was ocularly estimated as percent horizontal ground cover. All tree and shrub species combined and commercial tree species for timber were significantly taller in the 0.8-ha clearcuts than in the smaller cuts. Percent browsed was generally lower for all tree species groups and Rubus spp. in the 0.8-ha clearcuts than in the smaller clearcuts. Tree seedling diversity was relatively unaffected and percent fern cover was greatest in the 0.2-ha clearcuts. White-tailed deer use was relatively unaffected by clearcut size 1 and 2 years after harvest. If timber and wildlife are the primary objectives of small forest landowners, clearcuts smaller than 0.8-ha in size should be avoided.

Key Words: Odocoileus virginianus, white-tailed deer, clearcut size, regeneration, herbaceous cover, stocking rates.

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There have been numerous studies dealing with the effects of white-tailed deer browsing on forest regeneration covering a wide variety of harvesting practices (Shafer et al. 1961, Tierson 1966, Marquis 1974, Tilghman 1983, 1989, Trumbull 1988, Trumbull et al. 1989, Butterworth and Tzilkowski 1990). In some cases a complete absence of established tree seedlings has resulted where deer browsing impacts are intense. By using deer exclosures these studies strikingly illustrate that regeneration does occur where deer browsing is prevented.

Deer browsing produces economic losses for non-industrial private forest landowners (NIPF) by delaying establishment of the new stand and by reducing stocking levels subsequent to browsing. Forest landowners desiring to obtain the greatest economic benefit from their timber resource may be reluctant to try timber harvesting practices which result in net economic loss. However, with proper management, adequate forest regeneration along with economic gain can be secured.

Smith (1981) states that at least 0.2-ha circular clearcuts should be made to attain the silvicultural effects of larger clearcuts. Smaller clearcuts lack the diversity of species composition. Klein and Michael (1984) stated that improvement cut blocks should be at least 0.2 ha when timber and wildlife are the primary objectives. Sander and Clark (1971) concluded that openings should be 0.2 ha in size for adequate regeneration but added that 0.4-ha openings provide greater edge and therefore better wildlife habitat. Marquis (1987) found the size of individual openings ranging from 2.0 to 58.0 ha, to be unimportant in regeneration success. Ledoux et al. (1991) found that individual opening size of 0.4 ha or larger would be best from an economical standpoint for both cable (Ledoux et al. 1991) and ground-base logging technology (Ledoux et al. 1993).

This study was initiated to determine: (1) differences in height growth, species composition, and stocking density of woody plant species, (2) degree of deer browsing pressure, and (3) herbaceous ground covers in 4 different sizes of silvicultural clearcuts. Recommendations are developed determining the optimum size forest opening a NIPF can undertake and still obtain adequate forest regeneration, potentially benefit economically, and preserve various wildlife species habitats as well.

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STUDY AREA AND TREATMENTS

The study was conducted in the West Virginia University Forest located approximately 24 km northeast of Morgantown, West Virginia. Plots were located in a 22-ha stand of 60-70-year-old central Appalachian hardwood forest. Overstories were dominated by yellow poplar (Liriodendron tulipifera), northern red oak (Quercus rubra), chestnut oak (Q. prinus), scarlet oak (Q. coccinea), black cherry (Prunus serotina), red maple (Acer rubrum) and sugar maple (A. accharum) (Table 1). Understory data were not collected prior to harvest. Understories were assumed to be uniform throughout the stand but perhaps inadequate in meeting criteria given by Marquis and Bjorkbom (1982) to ensure proper regeneration after harvest cutting. The entire study site is on the north/northwestern aspect of the slope. White-tailed deer densities incorporating the study area were estimated to be approximately 13.8 deer/km^2 (35.9 deer/mi^2).

Sixteen, rectangularly-shaped plots were randomly selected for treatment. Four treatments were made, each containing 4 equally sized canopy openings: 0.2, 0.4, 0.6, and 0.8 ha. Silvicultural clearcuts were performed in each plot during December 1991 felling all woody stems greater than 2.54 cm dbh. Only the merchantable stems of marked trees were removed, leaving woody debris and unmerchantable parts of stems onsite. An approximate 30-m buffer strip was left between each clearcut.

METHODS

Tree seedlings, woody shrubs, and herbaceous ground cover were recorded during September 1992 and August 1993 on 25 systematically arranged sampling stations in each of the 16 clearcuts. Sampling stations were circular, with a radius of 1.8 m (0.001 ha). Data collected at each station consisted of the following: woody species and height class, origin of stem (seedling sprout, stump sprout, or advanced growth), and browsed or not. No distinction was made between stems of seedling or seedling sprout origin. All stems present in each stump sprout clump were counted, noting the dominant (tallest) stem.

Table 1. Pretreatment basal areas (m^2/ha)* of the overstory prior to treatment in different size clearcuts on the West Virginia University Forest, December 1991. Ranges are given inside parenthesis ( ).

	Clearcut size			
	0.8 ha	0.6 ha	0.4 ha	0.2 ha
White oak	0.3(0.0-0.8)	<0.1(0.0-0.1)	0.6(0.0-1.4)	0.0(0.0-0.0)
N. red oak	6.7(3.2-13.0)	2.8(0.9-4.6)	3.3(0.4-6.2)	7.9(6.3-9.4)
Chestnut oak	1.9(0.7-3.3)	1.9(0.0-5.0)	2.1(0.9-3.2)	1.8(0.2-3.1)
Scarlet oak	2.0(1.0-2.8)	3.0(1.1-5.3)	5.3(0.8-12.1)	4.6(0.9-8.7)
Yellow poplar	15.5(9.6-18.9)	19.6(12.1-24.6)	17.2(14.1-20.2)	15.8(9.0-25.6)
Maple (red and sugar)	3.3(1.3-5.9)	2.9(1.1-5.4)	2.5(1.5-3.8)	4.2(0.7-6.5)
Black cherry	2.1(0.6-3.5)	1.5(0.1-4.2)	2.0(0.7-2.9)	1.7(0.9-3.2)
Hickory spp.	0.3(0.1-0.8)	<0.1(0.0-0.1)	0.3(0.0-0.7)	0.3(0.0-0.7)
Sassafras	0.7(0.0-2.0)	1.1(0.1-1.9)	1.1(0.3-2.1)	0.2(0.0-0.8)
Miscellaneous	0.1(0.1-0.2)	0.2(0.1-0.3)	0.2(0.1-0.6)	0.5(0.1-0.9)
TOTAL	32.9	33.2	34.6	37.0

*basal areas are means of the 4 clearcuts in each clearcut size.

Heights of all woody tree and shrub species were categorized into 6 vertical classes: 0.0-0.3 m, >0.3-0.6 m, >0.6-0.9 m, >0.9-1.2 m, >1.2-1.8 m, and >1.8 m. Height growth was designated as the vertical distance from ground to the apex of the terminal shoot. Herbaceous plant cover was ocularly estimated as percent horizontal ground cover with radii increased to 8.0 m (0.02 ha) for evaluation of these items (Marquis et al. 1990).

Data were analyzed by all species combined, commercial tree species for timber, noncommercial tree species, commercial species most sensitive to deer browsing, and commercial species less sensitive to deer browsing. Abundance of all oak (Quercus spp.) and Rubus spp. were also analyzed separately.

Commercial species for timber included: black cherry, sugar maple, red maple, yellow poplar, northern red oak, sweet birch (Betula lenta), chestnut oak, white oak (Quercus alba), hickory spp. (Carya spp.), white ash (Fraxinus americana), and cucumbertree (Magnolia acuminata). Commercial species most sensitive to deer browsing included: sugar maple, red maple, sweet birch, and white ash. Commercial tree species less sensitive to browsing included black cherry only. Sensitivity to deer browsing by these tree species was based on studies conducted on the Allegheny Plateau by Marquis (1981, 1983), Marquis and Brenneman (1981), and Tilghman (1989). The noncommercial species category included: witch hazel (Hamamelis virginiana), tree-of-heaven (Ailanthus altissima), black locust (Robinia pseudo-acacia), American chestnut (Castenea dentata), spicebush (Lindera benzoin), black gum (Nyssa sylvatica), and sassafras (Sassafras albidum) in 1992 and these species plus ironwood (Ostrya virginiana), striped maple (Acer pensylvanicum), and sumac (Rhus spp.) in 1993.

Clearcuts were classified as adequately or inadequately stocked 1-2-year-old clearcuts as recommended by Marquis and Bjorkbom (1982). The requirements for adequate advance reproduction 1-2 years after cutting as described are:

I. The proportion of 1.8-m radius stations stocked with 25 stems total of commercial tree species is higher than the proportion of stations stocked with 5 stems over 0.9 m or 2 stems over 1.5 m.

II. At any time at least 70% of the 1.8-m radius stations contain at least 2 stems of commercial tree species over 1.5 m.

Since we did not categorize the height of stems to 1.5 m, 1.8 m was substituted for this portion of criteria.

The deer pellet count technique (Van Etten and Bennett, Jr. 1965) was conducted in May and October 1992 and May 1993 to determine white-tailed deer use in each clearcut. During each sampling period pellet groups were counted on 5 randomly-selected quadrants within each clearcut. Quadrants were 22 m long and 3.6 m wide (Van Etten and Bennett, Jr. 1965) having the longitudinal center on the centerpoint of an established transect line. Two observers were used to survey each quadrant simultaneously.

Analysis of variance by ranks was used to test for differences in density of stems per hectare above and below 0.9 m in height, percent herbaceous ground cover, and mean number of pellet groups found in the 4 cutting treatments. Duncan's new multiple range test (Dowdy and Wearden 1991) was used to make pairwise comparisons for the above mentioned items. All count data were square-root transformed along with all percent data arc-sin transformed (Dowdy and Wearden 1991). Significance levels were set at the alpha=<0.05 level for all statistical inferences.

The mean percent cover by sedge and grass was generally small (<1% at most sampling stations) in 1992 therefore significant differences in cover among the different clearcut sizes were not detectable in this year. Only sedge cover was inadequate for statistical analysis in 1993, leaving inference of grass coverage in each clearcut size possible.

RESULTS

Significant differences were detected in 1992 for density of stems/ha less than 0.9 m in height for all species combined and noncommercial tree species (Table 2). The 0.8- and 0.4-ha clear-cuts contained higher densities of stems/ha for all species combined than did the 0.6- and 0.2-ha clearcuts. The 0.8, 0.6-, and 0.4-ha clearcuts contained significantly higher stem densities than did the 0.2-ha clearcuts for

Table 2. Mean density (stems/ha) of regeneration (X 1,000) less than 0.9 m in height by tree category in different size clearcuts on the West Virginia University Forest, September 1992 and August 1993.

		Clearcut size			
		0.8 ha	0.6 ha	0.4 ha	0.2 ha
All species[a]	1992	102.0A[b]	82.8B	110.3A	79.2B
	1993	46.1A	49.4A	51.4A	38.8B
Commercial[c]	1992	59.3	56.3	65.6	56.3
	1993	19.1	18.8	21.6	21.5
Noncommercial[d]	1992	13.7A	10.2A	10.9A	6.3B
	1993	5.3A	5.8A	6.8A	3.2B
Sensitive[e]-	1992	8.4	9.6	6.7	10.9
Commercial[f]	1993	4.5B	4.2B	6.3B	11.0A
Less sensitive-	1992	18.5	12.3	18.5	15.2
Commercial[g]	1993	6.7	6.1	6.0	5.9
Oak spp.	1992	5.8	2.6	5.3	2.6
	1993	4.6B	2.4B	5.4A	2.2C
Rubus spp.[h]	1992	16.0	10.2	13.7	9.6
	1993	3.4	4.3	4.2	5.3

[a]All species include both commercial and noncommercial tree species plus Rubus spp., Smilax spp., and Vaccinium spp.
[b]Means within rows followed by different capital letters were significantly different ($P<0.05$).
[c]Black cherry, sugar maple, red maple, yellow-poplar, northern red oak, sweet birch, chestnut oak, white oak, hickory spp., white ash, and cucumbertree.
[d]Witch hazel, American chestnut, black gum, black locust, sassafras, and spicebush.
[e]Sensitivity to browsing by these tree species based on studies of deer browsing in Allegheny hardwood stands (Marquis 1981, 1983, Marquis and Brenneman 1981, Tilghman 1989).
[f]Sugar maple, red maple, white ash, and sweet birch.[g]Black cherry.[h]Rubus spp. were analyzed by height categories 0.0-0.3 and >0.3-0.6.

noncommercial tree species. Stem densities for commercial tree species, commercial tree species sensitive and less sensitive to browsing, and oak tree species were not significantly different between clearcut size in 1992 for this height category (Table 2).

In 1993, density of stems/ha less than 0.9 m in height for all species combined and noncommercial tree species again showed significant differences ($P<0.05$) between clearcut size (Table 2). The 0.8-, 0.6-, and 0.4-ha clearcuts were significantly higher in stem densities than the 0.2-ha clearcuts for both these tree species categories. Commercial tree species sensitive to browsing were significantly higher in the 0.2-ha clearcuts than in the 3 larger clearcut sizes in 1993. Also, density of stems/ha for oak species less than 0.9 m in height was significantly higher in the 0.8- and 0.4-ha clearcuts than in the 0.6- and 0.2-ha clearcuts. Commercial tree species and commercial tree species less sensitive to deer browsing showed no significant differences ($P>0.05$) between clearcut size and density of stems less than 0.9 m in 1993 (Table 2).

A summarization of results pertaining to density of stems greater than 0.9 m in height, idicates the 0.8-ha clearcuts contained more, taller stems than the 3 smaller clearcut sizes. This is generally true for most tree species categories (Table 3). In 1992, the 0.8-ha clearcuts contained a significantly higher density of stems for all species combined, commercial tree species, and commercial tree species sensitive to deer browsing than did the 0.6-, 0.4-, and 0.2-ha clearcuts

(Table 3). Densities of stems greater than 0.9 m for noncommercial tree species, commercial tree species less sensitive to deer browsing, and oak species were also higher (but not statistically) in the 0.8-ha clearcuts than in the smaller clearcut sizes.

In 1993, the 0.8-ha clearcuts contained a significantly higher density of stems greater than 0.9 m in height than did the 3 smaller clearcuts for all species combined, commercial tree species, and commercial tree species less sensitive to deer browsing (Table 3). The 0.8-ha clearcuts also contained a higher (but not statistically higher) density of commercial tree species sensitive to browsing in this tree height category. Differences in oak species and noncommercial tree species height growth were not clearly identifiable in 1993 (Table 3).

Table 3. Mean density (stems/ha) of regeneration (X 1,000) greater than 0.9 m in height by tree category in different size clearcuts on the West Virginia University Forest, September 1992 and August 1993.

		Clearcut size			
		0.8 ha	0.6 ha	0.4 ha	0.2 ha
All species[a]	1992	5.8Ab	1.7B	2.9B	2.6B
	1993	13.2A	8.4B	11.4B	7.1C
Commercial[c]	1992	4.8A	1.7B	2.3B	2.3B
	1993	10.6A	7.7B	8.7B	6.0B
Noncommercial[d]	1992	0.1	<0.1	0.1	<0.1
	1993	0.3B	<0.1B	0.8A	0.2B
Sensitive[e]-Commercialf	1992	0.6A	<0.1B	0.1B	O.1B
	1993	1.6	0.9	0.9	0.7
Less sensitive-Commercial[g]	1992	3.6	1.7	1.7	2.0
	1993	8.4A	5.9B	5.7B	5.1B
Oak spp.	1992	<0.1	<0.1	<0.1	-
	1993	0.1AB	<0.1B	0.5A	<0.1
Rubus spp.[h]	1992	0.1	<0.1	<0.1	<0.1
	1993	6.5A	9.4A	4.7B	2.8B

[a]All species include both commercial and noncommercial tree species plus *Rubus* spp., *Smilax* spp., and *Vaccinium* spp.
[b]Means within rows followed by different capital letters were significantly different ($P<0.05$).
[c]Black cherry, sugar maple, red maple, yellow-poplar, northern red oak, sweet birch, chestnut oak, white oak, hickory spp., white ash, and cucumbertree.
[d]Witch hazel, American chestnut, black gum, black locust, sassafras, and spicebush.
[e]Sensitivity to browsing by these tree species based on studies of deer browsing in Allegheny hardwood stands (Marquis 1981, 1983, Marquis and Brenneman 1981, Tilghman 1989).
[f]Sugar maple, red maple, white ash, and sweet birch.
[g]Black cherry.
[h]*Rubus* spp. were analyzed by height categories 0.0-0.3 and >0.3-0.6.

Multiple comparison tests depicted no significant differences in 1992 and 1993 in mean number of Rubus spp. stems/ha 0.0-0.3 m in height becoming established in each clearcut size (Table 2). Density of Rubus spp. >0.3-0.6 m was not significantly different in 1992, however, in 1993 the 0.8- and 0.6-ha clearcuts contained a significantly higher density of Rubus spp. in this height class than did the 0.4- and 0.2-ha clearcuts (Table 3).

Total percent herbaceous ground cover (ferns, grasses, sedges, and annual/perennial flowering and broad-leaved plants combined) was significantly higher ($P<0.05$) in 1992 in the 0.8- and 0.2-ha clearcuts (Table 4). The 0.2-ha clearcuts exhibited a significantly higher amount of fern cover, primarily hay-scented fern (Dennstaedtia punctilobula), bracken fern (Adiantum pedatum), and Christmas fern (Polystichum acrosticoides), than did the 3 larger clearcut sizes with a mean of 20.6% (Table 4). The 0.6-ha clearcuts had a significantly higher amount of annual, perennial, and broad-leaved plants than the other clearcut sizes.

In 1993, total herbaceous cover was not significantly different in the various clearcut sizes (Table 4). Fern cover was again significantly higher in the 0.2-ha clearcuts than in the 3 larger clearcut sizes. Annual/perennial flowering and broad-leaved plants were significantly higher in the 0.8-, 0.6-, and 0.4-ha clearcuts than in the 0.2-ha clearcuts (Table 4).

Only small differences in percent browsed of woody and herbaceous stems were detected in the varying clearcut sizes in both years of data collection. In 1992, no significant differences were detected in percent browsed for all species group categories (Table 5). Percent browsed for sensitive species to browsing in each clearcut size varied only slightly. The 0.6-ha clearcuts had the highest percent browsed for this species group (37.1%).

Browsing intensity for 1993 revealed a general decrease in percent browsed as clearcut size increased. Although no significant differences were detected in browsing intensity between clearcut size, the 0.8-ha clearcuts generally exhibited lower percent browsed than the 3 smaller clearcut sizes for all tree species categories (Table 5). Oak species percent browsed exhibited lower levels in the 0.8- and 0.6-ha clearcuts than in the 0.4- and 0.2-ha clearcuts.

Table 4. Percent ground cover of herbaceous plants in different size clearcuts on the West Virginia University Forest, September 1992 and August 1993.

		Clearcut size			
Ground cover		0.8 ha	0.6 ha	0.4 ha	0.2 ha
Fern	1992	11.1A[a]	9.3A	8.3A	20.6B
	1993	12.9A	11.6A	12.1A	22.8B
Grass	1992	<0.1	<0.1	<0.1	<0.1
	1993	6.8	8.4	11.0	6.8
Other[b]	1992	2.2A	3.6B	1.3AC	0.8C
	1993	0.7A	0.3A	0.5A	0.2B
Total	1992	18.8ab	14.5b	14.0b	24.6a
	1993	30.5	24.7	30.1	33.0

[a]Means within rows followed by different capital letters were significantly different ($P<0.05$).
[b]All annual/perennial flowering and broad-leaved plants.

Rubus spp. showed the most extreme differences in percent browsed in the different sizes of clearcuts. In 1992, the 0.8- to 0.2-ha clearcuts showed 35.3%, 48.0%, 70.3%, and 52.6% browsed, respectively (Table 5). Multiple comparison tests depicted no significant differences, however. Rubus spp. browsed in 1993 were again lower (but not statistically) in the 0.8-ha clearcuts than in the 0.6-, 0.4-, or 0.2-ha clearcuts (Table 5).

One year after harvest (1992) all 16 clearcuts except 1 were adequately stocked in regard to having a higher proportion of sampling stations stocked with 25 stems of commercial tree species than the proportion of stations stocked with 5 stems greater than 0.9 m or 2 stems greater than 1.8 in height (Table 6). Only 1 clearcut, 0.2 ha in size, contained less than 70% of the sampling stations stocked with at least 25 stems of commercial tree species, thus considered unsatisfactorily stocked.

In 1993, a combination of stocking criteria was used to determine adequacy of stocked clearcuts (refer to Table 6 for stocking levels of commercial tree species in each clearcut). Marquis and Bjorkbom (1982) recommend when the average of sampling stations stocked with 25 stems total and 5 stems over 0.9 m are both high, the average of these 2 criteria is the best indication of ultimate regeneration stocking.

Table 5. Mean percent browsed of woody stems by tree category and Rubus spp. in different size clearcuts on the West Virginia University Forest, September 1992 and August 1993.

		Clearcut size			
		0.8 ha	0.6 ha	0.4 ha	0.2 ha
All species[a]	1992	26.4	29.2	34.2	28.0
	1993	32.0	42.8	42.0	40.3
Commercial[b]	1992	28.7	23.2	28.4	30.1
	1993	20.5	21.9	32.4	34.3
Noncommercial[c]	1992	14.8	26.4	30.1	11.6
	1993	13.3	36.2	32.3	21.7
Sensitive[d] -commercial[e]	1992	26.9	37.1	19.6	28.1
	1993	47.6	63.0	76.2	60.0
Less sensitive -commercial[f]	1992	11.5	19.2	16.7	19.0
	1993	7.5	7.9	9.9	12.2
Oak species	1992	48.8	15.7	48.6	55.4
	1993	51.9	48.5	66.7	73.8
Rubus spp.	1992	35.3	48.0	70.3	52.6
	1993	48.2	70.5	50.7	65.4

[a]All species include both commercial and noncommercial tree species plus Rubus spp., Smilax spp., and Vaccinium spp.

[b]Black cherry, sugar maple, red maple, yellow-poplar, northern red oak, sweet birch, chestnut oak, white oak, hickory spp., white ash, and cucumbertree.

[c]Witch hazel, American chestnut, black gum, black locust, sassafras, and spicebush.

[d]Sensitivity to browsing by these tree species based on studies of deer browsing in Allegheny hardwood stands (Marquis 1981, 1983, Marquis and Brenneman 1981, Tilghman 1989).

[e]Sugar maple, red maple, white ash, and sweet birch.

[f]Black cherry.

Clearcuts with an average of 70% or more were considered adequately stocked, 50% or more marginal, and less than 50% the stand was inadequately stocked, having a poor chance of success. Clearcut "O", in the 0.2-ha clearcut size, does not have a high proportion of stations stocked with 5 stems greater than 0.9 m tall although it does have over 70% of stations stocked with 25 stems total (Table 6). This clearcut may be considered adequately stocked since very large numbers of stems, even in the smaller size classes, provide hope that some will escape deer browsing.

White-tailed deer pellet groups found during the May and October 1992 and May 1993 censuses are presented in Table 7. No significant differences (P>0 .05) were found in white-tailed deer use of various clearcut sizes for any of the 3 sampling periods. Pellet groups from all 3 sampling periods were combined to test for overall white-tailed deer use in each clearcut

Table 6. Percentage of sampling stations stocked with commercial tree species 1 and 2 years after harvest in different size clearcuts, judged by stocking criteria given by Marquis and Bjorkbom (1982).

	1992				1993		
Clearcut	25 stems total	5 stems >0.9 m	2 stems >1.8 m	Clearcut	25 stems total	5 stems >0.9 m	2 stems > 1 . 8 m
0.8 ha				0.8 ha			
A*	100	72	24	A*	84	92	68
G*	80	36	8	G**	52	60	28
H*	92	56	24	H**	60	68	64
J*	80	44	8	J**	44	56	44
Average	88	51	16		60	69	51
0.6 ha				0.6 ha			
C*	84	12	8	C***	48	44	20
E*	96	56	-	E*	76	84	52
F*	100	12	4	F***	24	32	16
L*	92	32	8	L*	84	92	56
Average	93	28	5		58	63	36
0.4 ha				0.4 ha			
B*	96	32	8	B**	56	72	44
K*	92	28	12	K**	4	56	32
M*	100	44	4	M*	88	76	48
N*	96	24	-	N**	60	64	28
Average	96	32	6		62	67	38
0.2 ha				0.2 ha			
D*	76	8	8	D***	24	40	8
I*	92	12	12	I*	64	76	56
O***	48	12	8	O*	76	36	20
P*	92	48	8	P*	76	64	48
Average	77	30	9		60	54	33

*Clearcut designated as adequately stocked 1-2-years after harvest.
**Clearcut designated as marginally stocked 1-2-years after harvest.
***Clearcut designated as inadequately stocked 1-2-years after harvest.

Table 7. White-tailed deer use of 16 clearcuts on the West Virginia University Forest 1991-1993.

	Deer pellet groups[a]/400-m^2sample			
Date sampled	0.8 ha	0.6 ha	0.4 ha	0.2 ha
4 May 1992	4.44[a]	3.84	4.51	3.41
8 October 1992	5.95	6.48	6.25	4.71
3 May 1993	6.12	6.84	6.53	6.42

[a]Values are mean values (square-root transformed) from the 4 clearcuts within each treatment (n=4).

size. No significant differences (P>0.05) were found in white-tailed deer use between each of the different clearcut sizes. The 0.2-ha clearcuts did receive slightly lower use by deer, exhibiting a mean of 23.5 pellet groups per clearcut. The 0.8- to 0.4-ha clearcuts averaged 30.3, 32.7, and 33.2 pellet groups per clearcut, respectively

DISCUSSION

Overall regeneration is more suitable in the 0.8-ha clearcuts than in smaller clearcuts. Reasons for this observation are not entirely understood. Miller (1982) states that colonizing species will be affected by patch size in that large patches may allow these species which disperse more time for reproduction. Thus, larger disturbances may favor colonizing species more than smaller disturbances. The resulting low stem densities of regeneration less than 0.9 m in height (Table 2) can be attributed to the natural dieback of smaller stems due to competition from crown closure. The slower growing, intermediate in shade tolerance, oak species do not exhibit this feature.

Differences in browsing intensity between clearcut size appears to be minimal. During the first year after harvest browsing intensity seemed to be determined by the number of stems available to white-tailed deer in a particular cut, i.e. the fewer stems/ha the higher percent browsed. An exception would be for Rubus spp. percent browsed (Table 5). The 0.4-ha clearcuts showed the highest percent browsed while exhibiting a large amount of Rubus spp. stems/ha (Table 2). In this case percent browsed seemed related to clearcut size.

Browsing intensity in 1993, 2 growing seasons after harvest, does appear to be related to clearcut size (Table 5). Vangilder et al. (1982) found white-tailed deer to avoid open areas at distances greater than 60-70 m to the nearest uncut forest edge. While the 0.8-ha clearcuts are only 40-50 m in diameter, deer could be avoiding these larger areas thus reducing the browsing pressure in these cuts. Further, white-tailed deer will feed selectively when food resources are in sufficient quantities. Since the 0.8-ha clearcuts contain higher stem densities than the 3 smaller clearcuts, deer may be feeding more selectively in these clearcut sizes thus attributing to the lower browsing percentages.

Stocking levels in 1992 were considered adequate for most clearcuts, regardless of size. However, the 0.2-ha clearcuts were on the lower spectrum of acceptance in meeting established criteria whereas the 0.8-ha clearcuts more easily met established criteria (Table 6). In 1993, conclusions concerning regeneration stocking and clearcut size can be made by speculation only. Two of the 0.8-ha clearcuts considered marginally stocked (see Table 6), contain large proportions of sampling stations stocked with 2 commercial stems greater than 1.8 m in height. These stands will undoubtedly become adequately stocked within 1 to 2 more years. Marginal clearcuts which do not contain high proportions of stations stocked with the latter criteria, may or may not become adequately stocked, although, there is reason to believe that some will reach over 1.8 m in height in the near future (Marquis and Bjorkbom 1982). The outcome of these clearcuts still remains questionable, however.

White-tailed deer are presumably hindering height growth in clearcuts with low proportions of all 3 stocking criteria 2 years after cutting. The impact of deer browsing is demonstrated by the delay in time required for these clearcuts to develop an adequate number of stems greater than 0.9 m in height since harvest. Any delay in stand establishment will cause economic losses for the private landowner. It may be necessary to employ some type of special treatment (fencing, planting, fertilization, and/or weed control) for these clearcuts to regenerate successfully without any further delay in stand establishment.

Possibly the most suggestive findings are related to higher percentages of fern cover in the 0.2-ha clearcut size. Horsley (1986) states that interference from hayscented fern results in poor survival and growth of black cherry seedlings on the Allegheny Plateau. Dense hayscented fern cover greatly reduces the quality and quantity of light that reaches the forest floor and reduces the amount of nitrate-nitrogen available to the seedlings (Horsley 1977a, 1977b). Horsley and Marquis (1983) showed that herbaceous plants, particularly ferns, caused significant interference with germination, survival, and growth of desirable woody species following both cuttings in a 2-cut shelterwood treatment. Ferns and grasses had no effect on birch (Betula spp.), however.

The increased amount of fern cover and the subsequently lower amount of Rubus spp. stems/ha in the 0.2-ha clearcuts may infer that deer browsing impacts are higher in these cuts than depicted by browsing intensity or white-tailed deer use based on pellet group counts. Research shows that fern cover may increase where deer browsing impacts are high while Rubus spp. correspondingly decreases. In areas protected from deer browsing existence by fern decreased while Rubus spp. increased in occurrence (Marquis and Grisez 1978, Tilghman 1983).

Overall, the larger, 0.8-ha clearcuts, do have a higher number of stems/ha greater than 0.9 m in height than the smaller clearcuts for all tree species categories. More woody stems will presumably escape deer browsing faster in the 0.8-ha cuts thus allowing normal forest regeneration to occur in these larger clearcut sizes. Harvesting stands at least 0.8 ha in size may permit the NIPF to meet timber harvesting goals as planned and possibly obtain economic benefits. Therefore, if the small landowner's objectives are to grow timber then cleared openings smaller than 0.8 ha in size should be avoided.

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